



# Tutorial: Integrating Systems Engineering with Earned Value Management

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**NDIA Systems Engineering Conference**  
**San Diego** **October 22, 2012**

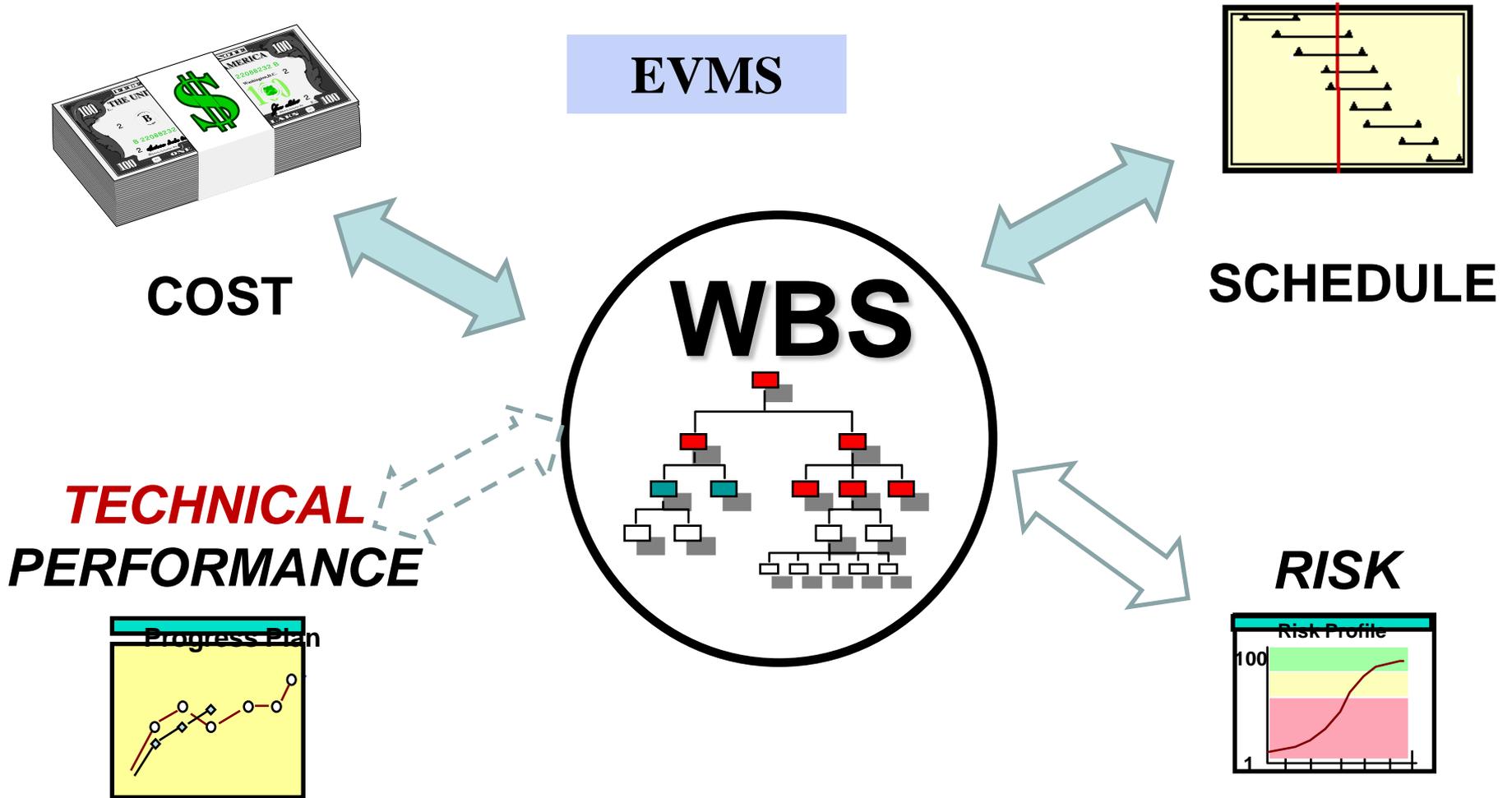


# Agenda

- **Link EV to Technical Performance/Quality**
- **Government Needs and Acquisition Reform**
- **Guidance in Standards, Models and DoD Guides**
- **Practical Application: 4 Opportunities**
  - **Base EV on Technical Performance**
  - **Account for Deferred Functionality**
  - **Track Systems Engineering Tasks Discretely**
  - **Plan Rework and Track it Discretely**
- **Acquisition Management and Reform**
- **Framework for Process Improvement**



# Does EVMS Really Integrate?





# Value of Earned Value



**“EVM data will be reliable and accurate only if:**

- The right base measures of technical performance are selected**
- and**
- Progress is objectively assessed” (a)**

(a) **“Integrating Systems Engineering With Earned Value Management”**  
in *Defense AT&L Magazine*, May 2004

# **Government Needs and Acquisition Reform**



# Office of Management and Budget (OMB)

- OMB Circular No. A-11, Section 300  
Planning, Budgeting, Acquisition and  
Management of Capital Assets
- Section 300-5
  - ***Performance-based*** acquisition management
  - Based on EVMS standard
  - Measure progress towards milestones
    - Cost
    - ***Capability to meet specified requirements***
    - Timeliness
    - ***Quality***



# Federal Acquisition Regulation (FAR) 2.101.b; EVMS

## EVMS Definition:

- Program management tool that effectively integrates project scope of work with:
  - Cost
  - Schedule
  - ***Performance*** elements
- Qualities and operating characteristics of an EVMS are described in ANSI-748 (EVMS)



**But ANSI-748 has  
*Performance/Quality gap***



# DoD EVM Report to Congress

**2009 Report: *DoD Earned Value Management: Performance, Oversight, and Governance* (1)**

***”Utility of EVM has declined to a level where it does not serve its intended purpose.”***

**Findings and Recommendations:**

- ***Inaccurate*** EVM status data provided by vendors
- Use ***Technical Performance Measures*** (TPM)
- Integrate ***Systems Engineering*** (SE) with EVM

**(1) Required by Section 887 of the of the FY 2009 NDAA, "Weapon Systems Acquisition Reform Act of 2009" (WSARA), Sept. 2009**



# EVM Challenges in Report to Congress

## Challenge: Technical Performance

- EVM can be an effective program management tool only if it is integrated with **technical performance**
- The engineering community should establish technical performance measures (**TPM**) that **enable objective confirmation that tasks are complete;**



# EVM Challenges in Report to Congress

## Challenge: Technical Performance

- If good TPMs are not used, programs could report 100 percent of earned value (or credit for work performed), even though they are behind schedule in terms of:
  - **validating requirements**
  - **completing the preliminary design**
  - **meeting weight targets**
  - **or delivering software releases that meet the requirements.**



# EVM Challenges in Report to Congress

## Challenge: Technical Performance

- The earned value completion criteria
  - must be based on **technical performance**
  - the **quality** of work must be verified, and
  - criteria must be defined clearly and unambiguously.
- The PM should ensure that the EVM process measures the **quality** and **technical maturity** of **technical work products** instead of just the quantity of work performed.



# EVM Challenges in Report to Congress

## Challenge: SE/Technical Baseline

EVM can be an effective program management tool only if

- the EVM processes are augmented with a rigorous **SE process**
- the **SE products** are costed and **included in EVM tracking**.

If the **SE** life-cycle management method is **integrated** with the planning of the **Performance Measurement Baseline (PMB)**, then EVM will accurately **measure technical performance** and **progress**.



# DoD Need: Integrated Testable Requirements

## Memo: Test & Evaluation of DoD Programs (1)

1. Improve **relationship** among testing, requirements, and **program management** communities
2. **Well defined, testable requirements**
  - Requirements development must be informed by technical feasibility and *rigorous trade-off analysis*.
  - Define requirements in ways that are clear and **testable**...should be achieved as early as possible.
  - Define requirements in ways that provide *meaningful increments of operational capability*.
  - Define requirements in ways that enable efficient program execution.

(1) 6/3/2011, signed by USD for AT&L, Ashton Carter and Director OT&E, J. Michael Gilmore.



# Deferred Functionality

GAO Report	Title	Findings and Recommendations
08-448	<b>Defense Acquisitions: Progress Made in Fielding Missile Defense, but Program Short of Meeting Goals (Missile Defense Agency (MDA))</b>	<b><u>Deferred Functionality</u></b> <b>MDA <i>did not track</i> the cost of work <i>deferred</i> from one block to another.</b> <ul style="list-style-type: none"><li>• <b>Cost of first block understated.</b></li><li>• <b>Cost of second block overstated.</b></li></ul>



# EVMS Quality Gap

## EVMS Standard shortfall (3.8):

- “EV is..measurement of *quantity* of work”
- “*Quality* and *technical* content of work performed are *controlled by other means*” !?

Quality Gap

## EVMS Standard shortfall (Guideline 2.2b):

Identify physical products, milestones,

- **technical performance goals** 
- “**or**” other indicators that will be used to measure progress.



Quality Gap



“or” not “and;” *technical performance is optional*



# EVMS Quality Gap

**EVMS Standard, Federal Acquisition Regulation (FAR) and Defense FAR Supplement (DFARS) are deficient:**

**No guidance or requirement to **link****

- **Reported EV**

**with**

- **Progress toward meeting *Quality/technical performance requirements***





# Management Reserve (MR) Quality Gap

**EVMS loopholes enable misuse of MR:**

**3.5.4 “MR is held for *unexpected growth* within the currently authorized *work scope*”**

***How is MR misused?***

- 1. Frequent causes of additional testing and rework:**
  - Unrealistic baseline assumptions
    - Low estimates of rework %, software defects etc.
  - Failure of design to meet technical requirements
- 2. MR used to *budget additional tests and rework, masked as “scope growth”***
- 3. Results: *Accurate progress and true cost overrun are not reported***



# **Standards, Models, Guides: Guidance on Quality**



# Standards, Models, and Guides

- **Processes for Engineering a System (ANSI/EIA-632)**
- **Standard for Application and Management of the SE Process (ISO/IEC 26702:2007/IEEE 1220) (a)**
- **Capability Maturity Model Integration (CMMI®)**
- **Guide to the Project Management Institute Body of Knowledge (PMBOK Guide®), 4<sup>th</sup> Edition**
- **SE Leading Indicators Guide, Version 2.0**
- **Space and Missile Systems Center (SMC) Standard SMC-S-001 Systems Engineering Requirements and Products**
- **USAF Weapon Systems Software Management Guidebook**
- **NAVAIR Using Software Metrics and Measurements for Earned Value Toolkit**

(a) Cited in DAG 4.2.1





# **Technical Baselines, Success Criteria, and Requirements Traceability**



# Requirements and Product Metrics

<u>ISO/IEC 26702</u>	<u>EIA-632</u>
6.8.1.5 Performance-based progress measurement	4.2.1 Req. 10: Progress against requirements
<p>6.8.1.5 d) Assess</p> <ul style="list-style-type: none"> <li>• <i>Development maturity</i></li> <li>• Product's ability to <i>satisfy requirements</i></li> </ul> <p>6.8.6 <i>Product metrics at pre-established control points:</i></p> <ul style="list-style-type: none"> <li>• Evaluate system <i>quality</i></li> <li>• <i>Compare to planned goals and targets</i></li> </ul>	<p>Assess <i>progress ...</i></p> <ul style="list-style-type: none"> <li>• Compare system definition <i>against requirements</i></li> </ul> <p>a) Identify <i>product metrics</i> and <i>expected values</i></p> <ul style="list-style-type: none"> <li>▪ <i>Quality</i> of product</li> <li>▪ Progress towards <i>satisfying requirements</i></li> </ul> <p>d) <i>Compare</i> results against <i>requirements</i></p>



# Requirements-based Success Criteria

## ISO/IEC 26702, (6.6): Success Criteria (CDR)

- Design solution meets:
  - *Allocated performance requirements*
  - *Functional performance requirements*
  - Interface requirements
  - Workload limitations
  - Constraints
  - Use models and/or prototypes to determine success



# SE Leading Indicators Guide: Requirements Trends

<b>Leading Indicator</b>	<b>Insight Provided</b>	<b>Base Measures</b>
<b>Requirements Validation Trends</b>	<b>Progress against plan in assuring that the customer requirements are valid and properly understood.</b>	<b>1. Requirements 2. Requirements Validated</b>
<b>Requirements Verification Trends</b>	<b>Progress against plan in verifying that the design meets the specified requirements.</b>	<b>1. Requirements 2. Requirements Verified</b>



# PMBOK® Guide

## 5 Project Scope Management

In the project context, the term scope can refer to

- **Product scope.** The *features* and *functions* that characterize a product, service, or result
- **Project scope.** The *work* that needs to be accomplished to deliver a product, service, or result with the specified features and functions.



# Manage the Technical Baseline

## DAG 4.5.1. Systems Engineering Plan

- Include the system's technical baseline approach
  - How the *technical baseline* will be developed, managed, and used to control
    - *System requirements*
    - Design integration
    - Verification
    - Validation
  - Discuss *TPMs and how they will be used to measure progress*



# Functional Baseline (DAG)

## What

- **Definition of the required system functionality**
  - Functional and interface characteristics of overall system
  - Verification required to demonstrate their achievement
- **Derived from the Capabilities Development Document (CDD)**
- **Includes**
  - Detailed functional performance specification for the overall system
  - Tests necessary to verify and validate system performance.

## When:

- **Established at System Functional Review (SFR)**
- **Verified at System Verification Review (SVR)**



# Allocated Baseline (DAG)

## What

- Definition of the configuration items (CI) making up a system
- All functional and interface characteristics allocated from the top level system or higher-level CIs
- Derived requirements
- *Performance* of each CI in the allocated baseline
- Tests necessary to verify and validate CI performance

When: At each CI's Preliminary Design Review (PDR)



# Product Baseline (DAG)

## What

**Necessary functional and physical characteristics of a CI**

- **Selected functional and physical characteristics designated for production acceptance testing**
- **Tests necessary for deployment/installation, operation, support, training, and disposal of the CI**
- **Initial product baseline includes “build-to” specifications for hardware (product, process, material specifications, engineering drawings and software (software module design— “code-to” specifications)**

## When:

- **At each CI’s Critical Design Review (CDR)**
- **System product baseline established at system-level CDR**



# USAF on Requirements Baseline



## 3.6.2 Requirements and Incremental Software Development

**b. Map/allocate the requirements into all planned builds.**

- **Failure to do so will increase likelihood that**
  - **Functionality will migrate to later builds**
  - **Initial delivery will not meet user expectations**
  - **Unplanned builds will become necessary**
  - **Delivery of full functionality will be delayed.**



# Trace Product Requirements Baseline to Plans



- CMMI<sup>®</sup>, PMBOK Guide<sup>®</sup> : Traceability and consistency

## Requirements

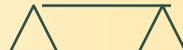


## Work

### •Project Plans

Task 1 

Task 2 

Task 3 

### •Activities

### •Work Products

Source: CMMI Requirements Management Process Area (PA), Specific Practice (SP) 1.5



# DoD Guides: Integrated Planning

**DoDI 5000.02, Operation of the Defense Acquisition System (POL)  
12/08**

**Defense Acquisition Guidebook (DAG)**

**Systems Engineering Plan (SEP) Preparation Guide 4/08**

**WBS Handbook, Mil-HDBK-881A (WBS) 7/30/05**

**Integrated Master Plan (IMP) & Integrated Master Schedule (IMS)  
Preparation & Use Guide 10/21/05**

**Guide for Integrating SE into DOD Acquisition Contracts (Integ SE)  
12/06**

**Defense Acquisition Program Support Methodology (DAPS) V2.0  
3/20/09**



# DoD: Technical Baselines And Reviews

DoD Policy or Guide	POL	DAG	SEP	WBS	IMP/IMS	Integ SE	DAPS
<b>Technical Baselines in IMP/IMS (Milestones):</b> <ul style="list-style-type: none"> <li>• Functional (SFR)</li> <li>• Allocated (PDR)</li> <li>• Product (CDR)</li> </ul>		X				X	X
<b>Technical Reviews:</b>							
• Event-driven timing of technical reviews	X	X	X	X	X	X	X
• Success criteria of technical reviews	X	X	X	X	X	X	X
• Include entry and exit criteria for technical reviews in IMP and IMS		X	X			X	X
• Assess technical maturity in technical reviews		X	X	X		X	



# DoD: Integrated Plans

DoD Policy or Guide	POL	DAG	SEP	WBS	IMP/IMS	Integ SE	DAPS
<b>Integrate SEP with:</b> <ul style="list-style-type: none"> <li>• IMP/IMS</li> <li>• <i>TPMs</i></li> <li>• EVM</li> </ul>		X	X		X	X	X
<b>Integrate WBS with</b> <ul style="list-style-type: none"> <li>• <i>Requirements specification</i></li> <li>• Statement of work</li> <li>• IMP/IMS/EVMS</li> </ul>		X		X	X	X	X
<b>Link risk management (including risk mitigation plans), technical reviews, <i>TPMs</i>, EVM, WBS, IMS</b>		X				X	X

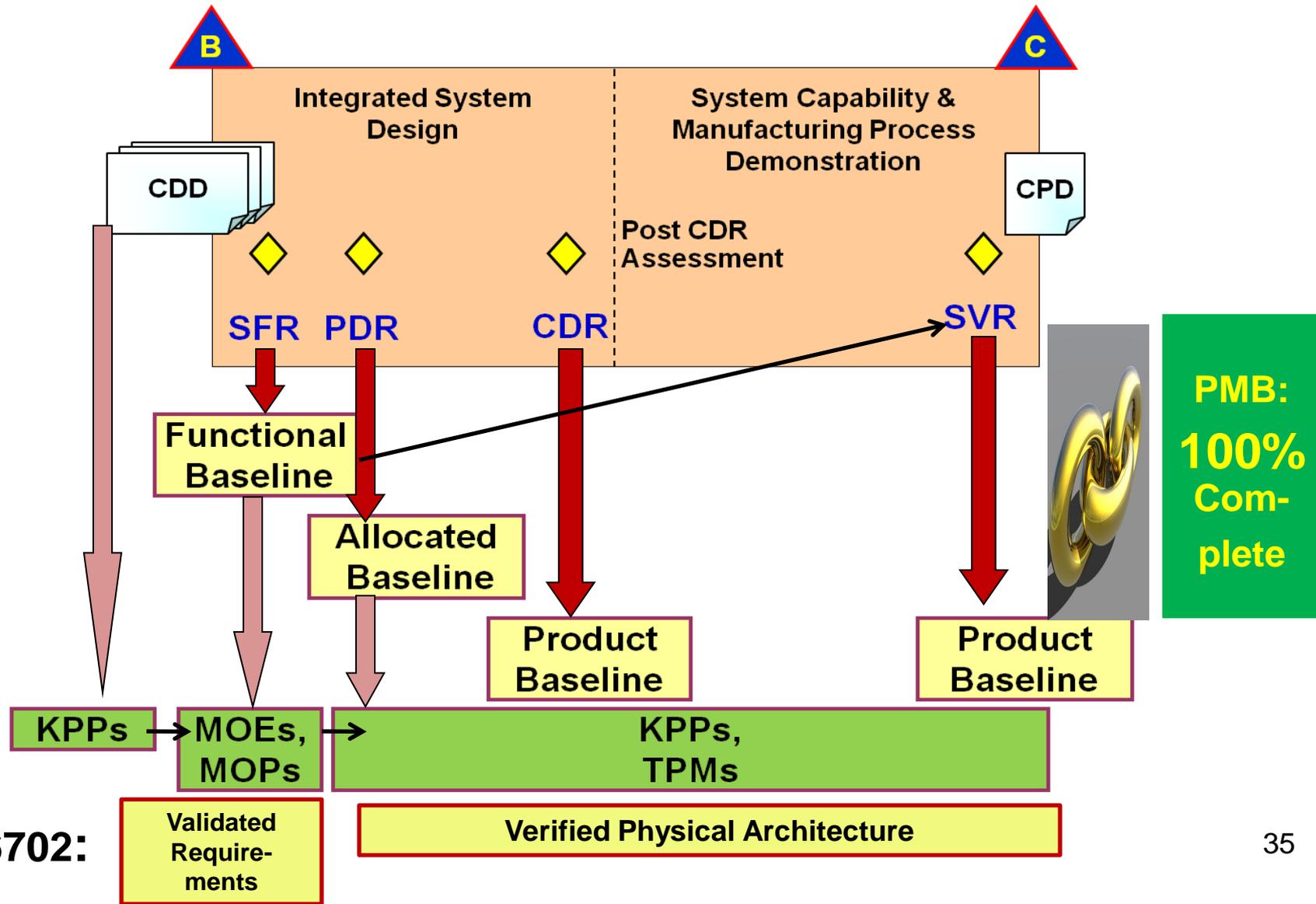


# DoD: Integrated Plans

DoD Policy or Guide	POL	DAG	SEP	WBS	IMP/IMS	Integ SE	DAPS
<b>Integrate SEP with:</b> <ul style="list-style-type: none"> <li>• IMP/IMS</li> <li>• <i>TPMs</i></li> <li>• EVM</li> </ul>		X	X		X	X	X
<b>Integrate WBS with</b> <ul style="list-style-type: none"> <li>• <i>Requirements specification</i></li> <li>• Statement of work</li> <li>• IMP/IMS/EVMS</li> </ul>		X		X	X	X	X
<b>Link risk management (including risk mitigation plans), technical reviews, <i>TPMs</i>, EVM, WBS, IMS</b>		X				X	X



# Link PMB to Technical Baselines, Reviews, and Measures



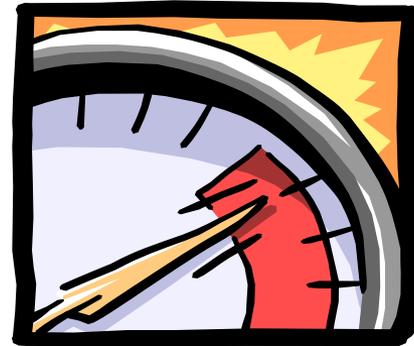


# Technical Performance Measures



# TPM

- **How well a system is achieving performance requirements**
- **Use actual or predicted values from:**
  - **Engineering measurements**
  - **Tests**
  - **Experiments**
  - **Prototypes**
- **Examples:**
  - **Payload**
  - **Response time**
  - **Range**
  - **Power**
  - **Weight**





# Technical Performance Measures (TPM)

<p><b><u>ISO/IEC 26702:</u></b>  <b><u>6.8.1.5,</u></b>  <b><u>Performance-based</u></b>  <b><u>progress</u></b>  <b><u>measurement</u></b></p>	<p><b><u>EIA-632: Glossary</u></b></p>	<p><b><u>CMMI for</u></b>  <b><u>Development</u></b>  <b>Requirements</b>  <b>Development</b></p>
<p><i>TPMs</i> are <b>key</b> to progressively assess technical progress</p>	<p><i>Predict</i> future value of <b>key technical parameters</b> of the end system based on current assessments</p>	<p><b><u>Specific Practice (SP)</u></b>  <b><u>3.3, Analyze</u></b>  <b><u>Requirements</u></b>  <b>Typical work product:</b>  <i>TPMs</i></p>
<p>Establish <b>dates</b> for</p> <ul style="list-style-type: none"> <li>– Checking progress</li> <li>– Meeting full conformance to requirements</li> </ul>	<p><b><i>Planned value</i></b> profile is time-phased achievement projected</p> <ul style="list-style-type: none"> <li>• <b><i>Achievement to date</i></b></li> <li>• <b><i>Technical milestone where TPM evaluation is reported</i></b></li> </ul>	<p><b>Subpractice:</b>  <b>Identify TPMs that will be tracked during development</b></p>



# TPMs in INCOSE SE Handbook

4.3.1.4: The architectural design baseline ...includes:

- TPM Needs – TPMs are measures tracked to influence the system design
- TPM Data – Data provided to measure TPMs

5.1.2.2 Systems Engineering Plan (SEP)

- TPMs are a tool used for project control
- The extent to which TPMs will be employed should be defined in the SEP.

5.7.2.4 TPMs

- Without TPMs, a project manager could fall into the trap of relying on cost and schedule status alone
- This can lead to a product developed on schedule and with cost that does ***not meet*** all ***key requirements***.
- Values are established to provide limits that give early indications if a TPM is out of tolerance.



# SE Leading Indicators Guide: Technical Measurement Trends

<b>Leading Indicator</b>	<b>Insight Provided</b>	<b>Base Measures</b>
<b>Technical Measurement Trends</b>	<b>Progress towards meeting Measures of Effectiveness (MOE) / Measures of Performance (MOP)/ Key Performance Parameters (KPP)s and TPM</b>	<b>Values of Technical Measure</b>

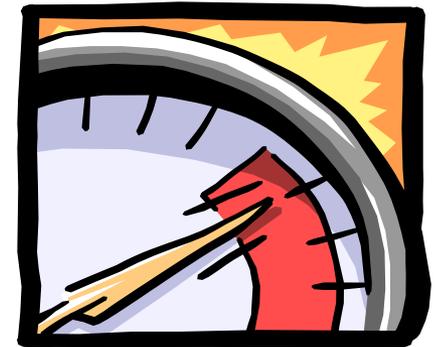
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# TPMs in DAG

## DAG:

- Performance measurement of WBS elements, using objective measures:
  - *Essential for EVM* and Technical Assessment activities
- *Use TPMs* and Critical Technical Parameters (*CTP*) to report progress in achieving milestones
- Plan is defined in terms of:
  - Expected performance at specific points
    - Defined in the **WBS** and **IMS**
  - **Methods of measurement** at those points
  - Variation limits for corrective action.





# TPMs in DAG

- TPM parameters to be tracked
  - *Cost drivers* on the program,
  - On the *critical path*
  - Represent *high technical risk* items.
- Contract Deliverable
  - *Report of TPMs* that are traceable to:
    - Needs of the operational user
    - Key Performance Parameters (KPP), Critical Technical Parameters
    - Key system attributes
- Contractor's internal TPMs
  - *TPMs at a more detailed level*



# PMBOK TPM Guidance

## 11.6.2.4 Technical Performance Measurement

- TPM compares technical accomplishments during project execution to the ... schedule of technical achievement.
- It requires definition of objective, quantifiable **TPMs** which can be used to compare actual results against targets (11.6.2.4).



# **SE Tasks, Work Products, and Completion Criteria**



# Validated Requirements (Functional) Baseline

## ISO/IEC 26702, (6.1, 6.2): Work Products

- Customer expectations
- Project, enterprise and external constraints
- *Operational scenarios*
- *MOEs*
- Interfaces
- *Functional requirements*
- *MOPs*
- Modes of operation
- Design characteristics
- Documented trade-offs



# SFR Success Criteria (CMMI/DAG)

<p><b>Requirements Development</b></p>	<p><b>SG 3: Analyze and Validate Requirements</b></p>	<p><b>DAG</b></p>
<p><b>SP 3.2</b></p> <p><b>Establish a Definition of Required Functionality</b></p>	<p><b>Example work products:</b></p> <ul style="list-style-type: none"> <li>• Functional architecture</li> <li>• Activity diagrams and use cases</li> </ul> <p><b>Subpractices</b></p> <ol style="list-style-type: none"> <li>1. Analyze and quantify functionality required by end users</li> <li>2. Allocate functional and performance requirements to functions and subfunctions</li> </ol>	<p><b>4.2.3.1.6.2</b></p> <p><b>Establish Configuration Baselines - SFR success criteria</b></p>





# PDR Success Criteria

## DAG 4.3.2.4.2.3 (partial)

- Preliminary design satisfies the CDD
- System **allocated baseline** established and documented to enable detailed design to proceed with proper configuration management
- Program schedule executable (technical/cost risks)
- Producibility assessments of key technologies completed
- Program executable with
  - Existing budget
  - Approved system allocated baseline
- Risks known and manageable for testing

Note: Software success criteria discussed in later section



# PDR, CDR Success Criteria (CMMI/DAG)

 <b>CMMI Requirements Development</b>	<b>SG 2: Develop Product Requirements</b>	<b>DAG</b>
<b>SP 2.2</b>  <b>Allocate product component requirements</b>	<b>Example work products:</b> <ul style="list-style-type: none"> <li>• Requirement allocation sheets</li> <li>• Design constraints</li> <li>• <b>Derived requirements</b></li> </ul> <b>Subpractices</b> <ol style="list-style-type: none"> <li>1. <b>Allocate requirements to functions</b></li> <li>2. <b>Allocate requirements to product components</b></li> </ol>	<b>4.2.3.1.6.2</b>  <b>Establish Configuration Baselines –</b>  <b>PDR, CDR Success Criteria</b>



# CDR Success Criteria

## ISO/IEC 26702, (6.6): Success Criteria (CDR)

- Design solution meets:
  - *Allocated performance requirements*
  - *Functional performance requirements*
  - Interface requirements
  - Workload limitations
  - Constraints
  - Use models and/or prototypes to determine success



# CMMI Example SE Work Products



## Requirements Development PA

- **Prioritized customer requirements**
- **Customer constraints on the conduct of verification**
- **Customer constraints on the conduct of validation**
- ***Activity diagrams and use cases***
- **Derived requirements**
- **Relationships among derived requirements**
- ***Product requirements***
- **Definition of *required functionality* and *quality attributes***
- ***TPMs***



# CMMI Example SE Work Products



## Requirements Management PA:

- *Requirements traceability matrix (RTM)*

## Verification PA:

- *Verification methods* for each selected work product
- *Verification criteria*
- *Exit and entry criteria for work products*
- Verification results

## Measurement and Analysis PA:

- *Measurement objectives*
- *Specifications of base and derived measures*



# CMMI Example SE Work Products



## Technical Solution PA:

- Documented relationships between *requirements* and **product components**
- Product component design
- Interface specification criteria
- Implemented design



# Practical Application



# Four Opportunities

## Specific Opportunities Underlying the Challenges

**1. Base EV on Technical Performance**

**2. Account for Deferred Functionality**

**3. Track SE tasks discretely**

**4. Plan rework and track it discretely**

↓  
**2 steps**

**Top Down Planning**

**Measure Interim Progress**



# Proposed Solution for Basing EV on Technical Performance

## Top Down Planning

1 of 3

- Make the IMP a contractual requirement with **correct, requirements-based** accomplishment criteria
  - Examples:
    - MOPs defined at SFR
    - TPMs defined at PDR
    - At CDR, subsystem design is finalized and meets all allocated design, interface and all derived requirements
- Use the IBR to reach agreement on the **accomplishment** criteria for IMP events



# Proposed Solution for Basing EV on Technical Performance

## Top Down Planning

2 of 3

- **Require that requirements-based accomplishment criteria for major technical reviews are traceable from:**

**IMP → IMS → Work Package**



# Proposed Solution for Basing EV on Technical Performance

## Top Down Planning

3 of 3

- **When planning incremental functionality**
  - Document the functional requirements baseline of each block, version, or build (all called “builds”)
  - Establish interim and completion build milestones based on functional requirements
  - Establish work packages for builds that support the IMS milestones

**Note: Contractual requirement communicated via IMP.**



# Example 1: Work Package Completion Tied to CDR Success Criteria (1 of 4)

- **90% of engineering design drawings are complete and releasable to manufacturing.**
- **All stakeholders agree that the design is producible.**
- **Completion of component design reviews:**
  - **Enclosure**
  - **Radio transmitter**
  - **Battery**
  - **Control**
  - **Software**



# Ex 1: Work Package Completion Tied to CDR Success Criteria (2 of 4)

- **Prototype of enclosure demonstrated that the design meets the following requirements (RQMT) in the Requirements Data Base (RDB) :**
  - **RQMT 001: Weight: no greater than 40 lb**
    - **PROD 1: The overall weight of the Mobile C2 Center shall not exceed 40 lbs**
  - **RQMT 2: Waterproof in continuous rain**
    - **PROD 2: The Mobile C2 Center shall be waterproof in continuous (up to 2 hours) driving rain with a wind speed of up to 65 miles per hour and rainfall of up to 4 inches per hour.**
      - **ENCL 2: The Mobile C2 Center shall be waterproof in continuous (up to 2 hours) driving rain with a wind speed of up to 65 miles per hour and rainfall of up to 4 inches per hour.**



# Ex 1: Work Package Completion Tied to CDR Success Criteria (3 of 4)

- RQMT 3: Impact resistant
  - PROD 3: The Mobile C2 Center shall show no damage after at least 3 successive impacts with a hard abrasive surface of up to 15 lbs./sq. in.
  - ENCL 3: Same as above.



# Ex 1: Work Package Completion Tied to CDR Success Criteria (4 of 4)

- **RQMT 4: Software (SW) Functionality: Terrain)**
  - **SW integration testing results demonstrated that the SW meets the following functional (FUNC) requirements:**
    - Func 7: The Mobile C2 center shall allow the user to select a visible image of the terrain being surveilled.**
    - FUNC 8 The Mobile C2 center shall allow the user to select an infrared image of the terrain being surveilled.**
    - FUNC 9 The Mobile C2 center shall allow the user to select either a high-pass or a low-pass filter to enhance the visible image of the terrain being surveilled.**
  - **All stakeholders agree that there are no critical, Priority 1 SW defects**



# Opportunity 1: Base EV on Technical Performance

## Measure Interim Progress

### EVMS Issue:

**2. Interim EV progress may not be based on actual progress towards achieving 100% of baselined technical performance or functionality.**

**Basing interim EV on technical performance or quality is optional; rarely used in practice. Typical % complete may fail to provide early warning.**



# Solution for Basing EV on Technical Performance

## Measure Interim Progress

1 of 2

- **Establish objective linkage between technical performance planned values and EVM:**
  - For physical objectives, use TPMs
  - For planned functionality, base on functional requirements
- **Compare reported EV with technical performance**
- **If EV exceeds technical performance:**
  - Do root cause analysis to determine reasons for disconnect
  - Refine base measures of EV to reflect technical performance



# Solution for Basing EV on Technical Performance

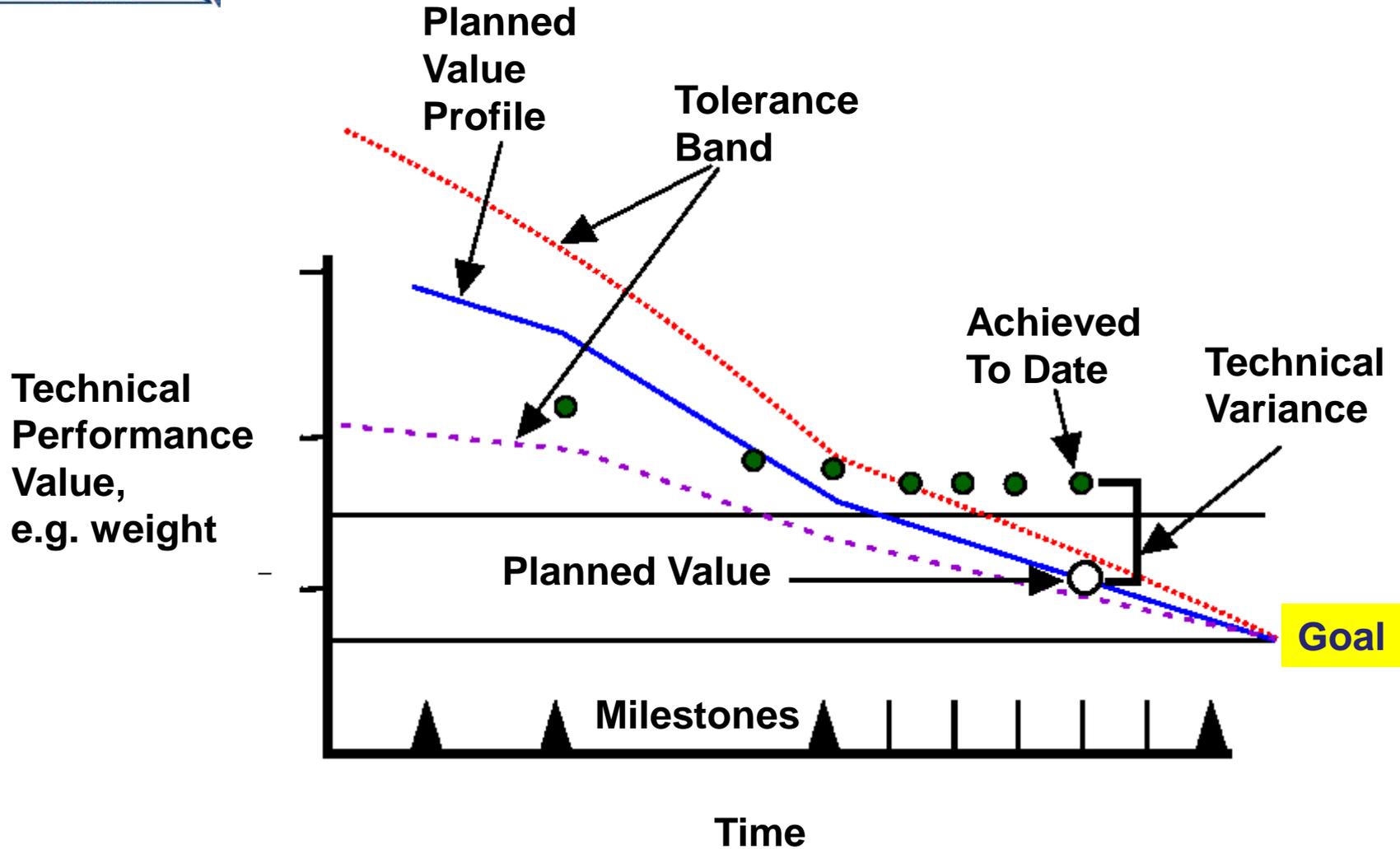
## Measure Interim Progress

2 of 2

- If behind schedule on technical performance, perform variance analysis and develop corrective actions
  - Revise ETC *forward*  $\longrightarrow$  for work packages with corrective actions
  - Correct EV to reflect technical performance status
    - Backwards  $\longleftarrow$  adjustment to EV is appropriate for work packages with corrective actions
    - Enables use of EV to track corrective actions to resolution and closure



# TPM Performance vs. Baseline





## Ex 2: EV Based on Drawings and TPMs (1 of 8)

- **SOW: Design a component, Enclosure, with 2 TPMs:**
  - Maximum (Max) weight
    - Planned Value (PV): 6 lb. (May)
  - Max dimensions (length + width + height)
    - PV: 32 inches (when 80% drawings complete, April)
- **Enabling work products: 50 drawings**
- **BAC: 2000 hours**
  - Drawings: 40 hours/drawing @ 50 = 2000
  - If TPM PVs *not* met on schedule:
    - Develop recovery plan (RP)
    - Negative adjustment to EV based on RP



## Ex 2: EV Based on Drawings and TPMs (2 of 8)

### Recovery Plan Adjustment to EV:

1. Develop RP to reduce weight from 7 to 6 lb.
2. Determine duration and completion date of RP
3. Move ETC *forward* to completion date of RP
4. Make negative adjustment to cum. BCWP =  
(duration of RP) x BCWS/period = (*backwards* adjustment)

### Example:

- If RP = 1.5 months and
- BCWS = 400 / month
- Then RP *backwards* EV adjustment = - 600

### Benefits:

1. Cum. EV reflects realistic schedule variance
2. Track RP with EV



# Ex 2: EV Based on Drawings and TPMs (3 of 8)

Schedule	Total	Jan	Feb	Mar	Apr	May	Total
<u>Drawings</u>							
Drawings/ period	50	8	10	12	10	10	50
<b>Meet requirements:</b>							
Weight	6 lb.						
Dimensions	32 in.						



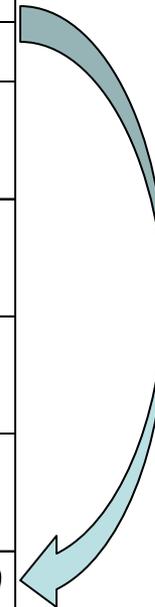
## Ex 2: EV Based on Drawings and TPMs (4 of 8)

Date	April 30	May 31
Drawings completed	41	49
Weight met	No	No
Dimensions met	Yes	Yes



## Ex 2: EV Based on Drawings and TPMs (5 of 8)

Design (drawings)	Jan.	Feb.	Mar.	Apr.	May	Total
Planned drawings cur	8	10	12	10	10	50
Planned drawings cum	8	18	30	40	50	
BCWS cur	320	400	480	400	400	2000
BCWS cum	320	720	1200	1600	2000	2000
Actual drawings completed cur	9	10	10	12	8	
Actual drawings completed cum	9	19	29	41	49	
EV (drawings) cum	360	760	1160	1640	1960	
RP EV adjustment				0	-600	
Net EV cum	360	760	1160	1640	1360	1360



**SV = -  
640**



## Ex 2: EV Based on Drawings and TPMs (6 of 8)

May schedule variance (drawings and requirements):

- 1 drawing behind schedule - 40
  - Dimensions requirement met - 0
  - Weight requirement *not* met and recovery plan will extend ETC
    - RP EV adjustment =  $1.5 \times (-400/\text{month}) =$  - 600
- Schedule variance (SV) - 640



## Ex 2: EV Based on Drawings and TPMs (7 of 8)

### May comprehensive schedule variance analysis

- **Primary driver of SV is weight reduction (- 600)**
- **Recovery plan**
  - Use magnesium alloy instead of aluminum; 1 lb. reduction
  - 15 drawings to be reworked; dimensions and interfaces
- **Recovery plan will take 6 weeks**
  - Reflected in negative EV adjustment and IMS status
- **Typical EAC and schedule impacts:**
  - ETC extended 6 weeks until July 15
  - Non-recurring EAC: + \$50K
  - Recurring material and fabrication costs: \$800/unit
  - Schedule impact on CDR; slip 4 weeks



# Ex 2: EV Based on Drawings and TPMs (8 of 8)

Schedule	Total	Jan	Feb	Mar	Apr	May	Jun	Jul
Plan: Drawings/ period	50	8	10	12	10	10		
Weight	6 lb.							
Original EV cum		360	760	1160	1640	1960		
Rework Drawings							10	5
Negative EV						-600		
Adjusted EV						1360		
IMS	Before After							



# EVMS Guideline Inhibits Accurate Reporting

- Most practitioners, and DCMA, believe that it is wrong (non-compliant) to make negative adjustments to EV
- Some contractors and DCMA require Program Office and DCMA prior approval
- They misinterpret EVMS Guideline 30 by focusing on the first statement below and ignoring the second statement:
  - Control retroactive changes to ...work performed.
  - ...Adjustments should only be made..to *improve the accuracy* of performance measurement data.
- This misinterpretation inhibits accurate reporting and condones overstatement of true progress when previously reported technical performance is no longer true



# TPMs Work for Software Too

## Same technique works for hardware:

- **Substitute computer software units for drawings**
- **Use SW TPMs such as:**
  - Defect density
  - Throughput



## **Ex 3: TPM at Higher WBS Level (1 of 3)**

- **Design of a component at the work package level**
- **Completion of the component design depends on**
  - **Achieving allocated TPMs values at**
    - **Component level (work package) and**
    - **Configuration Item (CI) level (summary level)**
- **EV depends on planned TPM values achieved at both levels**



## Ex 3: TPM at Higher WBS Level (2 of 3)

- **Assumptions:**
  - **Component 1 in Example 1 is one of 5 components (work packages) that form a CI**
  - **CI's TPM objective is 40 lb.**
  - **Systems Engineering Plan states:**
  - **Some components may be overweight at completion if there are offsets in other components (Comp) as long as the total CI weight does not exceed 40 lb.**



## Ex 3: TPM at Higher WBS Level (3 of 3)

Work Pkg/ Comp	TPM PV (lb)	Comp Mile- stone	CI Mile- stone	RP Nega- tive EV
<b>1 Enclosure</b>	<b>6</b>	<b>April</b>	<b>May</b>	<b>(a)</b>
<b>2 Transmitter</b>	<b>10</b>	<b>April</b>	<b>May</b>	<b>(a)</b>
<b>3 Battery</b>	<b>4</b>	<b>May</b>	<b>May</b>	<b>(a)</b>
<b>4 Controller</b>	<b>20</b>	<b>May</b>	<b>May</b>	<b>(a)</b>
<b>Total</b>	<b>40</b>			

**(a) If component will be redesigned in Recovery Plan, make backwards adjustment to EV based on forward ETC revision**



# Opportunity 2: Deferred Functionality

## EVMS Issue:

**EV may not account for deferred functionality from one build, release, or block to another.**



# Solution for Account for Deferred Functionality

- **Account for deferred functionality (in a block or release)**
  - **If build is behind schedule and is released short of planned functionality:**
    - **(Preferred) Take partial EV and close work package**
      - **Transfer deferred scope and Budgeted Cost of Work Remaining to first month of work package of next increment**
        - » **EV mirrors technical performance**
        - » **Schedule variance is retained**
      - **Disclose shortfall and slips on higher schedules**
    - or**
    - **Take partial EV and leave work package open**



# Solution for Account for Deferred Functionality

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  - or
  - **Take partial EV and leave work package open**



# NAVAIR on Deferred Functionality

## NAVAIR 3.1.4 Deferred Functionality or Requirements

Deferring functional requirements has the following impacts:

1. If all the requirements planned for a phase are not completed, then the earned value for these deferred requirements cannot be earned as part of the build.
5. Although requirements may be deferred to a subsequent build, the earned value must continue to show a behind schedule condition. The deferred effort should not be replanned beyond the current month.<sup>4</sup>

***“No matter what software measures are used to drive EV, requirements must also be used if actual program status is to be determined.”***



## Ex 4: Deferred Functionality (1 of 5)

**SOW: Software Requirements in 2 Builds:**

	<u>Build</u>	<u>Allocated Req.</u>	<u>Budget/Req.</u>	<u>BAC</u>
A		100	5	500
B		60	5	300



# Ex 4: Deferred Functionality (2 of 5)

Plan and Performance	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
<b>Budget/Req: 5</b>							
<b>Build A</b>							
Planned Reqs met	25	25	25	25	0	0	100
BCWS - cur	125	125	125	125			500
BCWS - cum	125	250	375	500			
<b>Build B</b>							
Planned Reqs met				20	20	20	60
BCWS - cur				100	100	100	300
BCWS - cum				100	200	300	



# Ex 4: Deferred Functionality (3 of 5)

Plan and Performance	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Total
<b>Build A</b>							
Planned Reqs met	25	25	25	25	0	0	100
Actual Reqs. Met - cur	20	20	25	25	0	0	90
BCWS - cur	125	125	125	125	0	0	500
BCWS - cum	125	250	375	500			500
EV-cur	100	100	125	125			
EV - cum	100	200	325	450			450

## Schedule Variance (SV)

Reqs met - cur	-5	-5	0	0	0	0	-10
SV - cur	-25	-25	0	0			
SV - cum	-25	-50	-50	-50			-50

**Corrective  
Action:**

**1. Release  
Build A.**

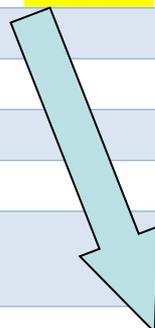
**2. Move 10  
reqs  
to Build B.**



# Ex 4: Deferred Functionality (4 of 5)

## Deferred Functionality Replan

Plan and Performance	Period 3	Period 4	Period 5	Period 6	Total
<b>Close Build A work package:</b>					
<b>Schedule variance:</b>					
Reqs met - cum	-10				
SV - cum	-50				
<b>Build B before replan</b>					
Planned Reqs met		20	20	20	60
BCWS - cur		100	100	100	300
<b>Plus transfer from Build A</b>					
Deferred Reqs		+ 10			+ 10
PV remaining		+ 50			+ 50
<b>Build B after replan:</b>					
Planned Reqs met		30	20	20	70
BCWS- cur		150	100	100	350



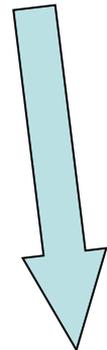
**Transfer BCWS to 1<sup>st</sup> month of receiving work package to retain negative schedule variance (behind schedule)**



# Ex 4: Deferred Functionality (5 of 5)

## Deferred Functionality Replan

Plan and Performance	Period 3	Period 4	Period 5	Period 6	Total
<b><u>Build B after replan:</u></b>					
Planned Reqs met		30	20	20	70
BCWS - cur		150	100	100	350
<b><u>Period 4 performance:</u></b>					
Reqs. Met - cur		20			
EV - cur		100			
SV		-50			



**The work package will still be behind schedule at the end of Period 4 if only the original 20 requirements are met**

**3 Track SE tasks discretely**



# **Solution to Track SE Tasks Discretely (1 of 3)**

- **Include significant accomplishments and accomplishment criteria for SE tasks and work products in IMP**
- **Include progress towards completing SE work products in IMS and work packages**
  - **Typical SE work products include:**
    - **System architecture (functional and physical)**
    - **Interface controls**
    - **Specifications**
    - **Trade studies**
    - **Test procedures**



# **Solution to Track SE Tasks Discretely (2 of 3)**

- **For SE work products with IMP accomplishment that include product requirements, derived requirements and allocated requirements:**
  - **Develop requirements-based, time-phased BCWS for interim performance measurement**
  - **Base EV on requirements status in requirements data base:**
    - **Typical examples**
      - **Defined**
      - **Early Validated**
      - **Determined verification method**
      - **Approved**
      - **Allocated**
      - **Traced to test procedure**



# **Solution to Track SE Tasks Discretely (3 of 3)**

- **For work packages that result in SE work products that are technical measures, base EV on progress towards meeting the IMP criteria for their completion.**

## **Examples:**

- **MOEs**
- **MOPs**
- **TPMs**



# Correlate with SE Tasks

- **Base EV on progress of**
  - Enabling work products (drawings, code) and
  - RM/SE tasks and work products
- **Use Requirements Traceability Matrix**
  - Set milestones for RM/SE work products
  - Measure progress vs. plan
- **Compare SE EV with EV at pertinent WBS levels**
  - SE progress is like a tracking stock for the whole program
  - **Red Flag**: if WBS level progress > RM/SE progress



# Ex 5: Requirements Management (RM) 1 of 3

- Discretely measure SE RM tasks
- Use RTM to control plan

<b>% of Budget</b>	<b>RM Task</b>
15	Define
15	Validate
15	Determine verification (ver) method
0	Approve
20	Allocate
15	Trace to test procedure (ver document)
0	Test
20	Verify

- Key indicator of project performance



# Ex 5: Time-Phased Budget 2 of 3

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
<b>Enclosure</b>									
<b>Schedule</b>									
<b>Defined</b>		3							
<b>Validated</b>			2	1					
<b>Verif. Method</b>				1	2				
<b>Allocated</b>						3			
<b>Traced to Verif.</b>							3		
<b>Verified</b>								3	
<b>BCWS current</b>	<b>Budget/Activity</b>								
<b>Defined</b>	12	36							36
<b>Validated</b>	12		24	12					36
<b>Verif. Method</b>	12			12	24				36
<b>Allocated</b>	16					48			48
<b>Traced to Verif.</b>	12						36		36
<b>Verified</b>	16							48	48
<b>Total</b>		36	24	24	24	48	36	48	240
<b>BCWS cumulative</b>		36	60	84	108	156	192	240	



## Ex 5: Earned Value 3 of 3

		Jan.	Feb.	Mar.	Apr.	May
<b><u>Enclosure</u></b>						
<b><u>Completed</u></b>	<b>Budget/Activity</b>					
<b>Defined</b>	<b>12</b>		<b>3</b>			
<b>Validated</b>	<b>12</b>				<b>1</b>	<b>1</b>
<b>Verif. Method</b>	<b>12</b>				<b>1</b>	
<b><u>BCWP cumulative</u></b>		<b>0</b>	<b>36</b>	<b>36</b>	<b>60</b>	<b>72</b>
<b><u>BCWS cumulative</u></b>		<b>36</b>	<b>60</b>	<b>84</b>	<b>108</b>	<b>156</b>
<b><u>Schedule Variance</u></b>		<b>-36</b>	<b>-24</b>	<b>-48</b>	<b>-48</b>	<b>-84</b>

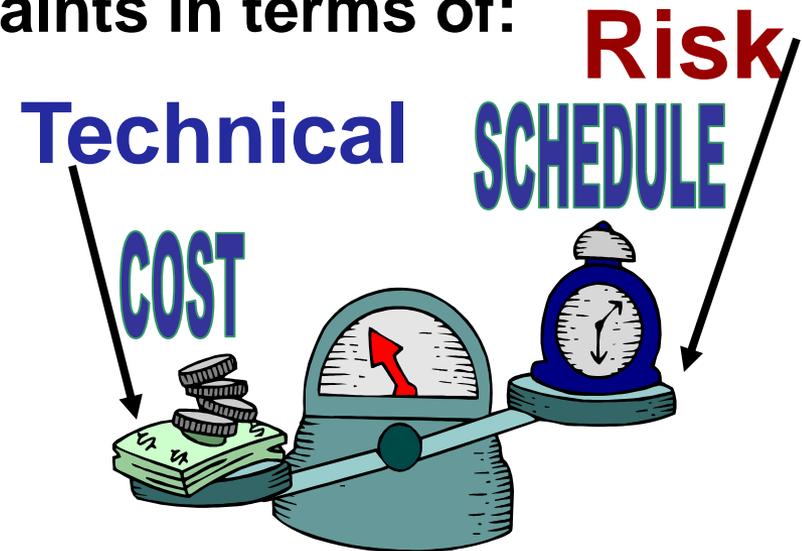


# Trade Studies



# Trade Studies

- Performed during all phases of the engineering life cycle
- Provide objective foundation to select an approach to the solution of an engineering problem.
- **Systems definition:** Identify the recommended set of requirements and constraints in terms of:
  - Risk
  - Cost
  - Schedule
  - Performance impacts
- Design solution





# Trade Studies and Requirements

- **Typical trade results:**
  - **Select user/operational concept**
  - **Select system architectures**
  - **Derive requirements**
    - **Alternative functional approaches to meet requirements**
    - **Requirements allocations**
  - **Cost analysis results**
  - **Risk analysis results**



# Trade Study is a Work Product

- **Outcome is usually a recommendation that is needed to make a decision.**
- **Decision constrains and guides further progress.**
- **Work product: documented trade study results.**
- **Engineering processes should include a process and structured approach for performing trade studies.**
  - **Process should include both interim and final work products that can be:**
    - **Planned, scheduled**
    - **Measured discretely.**



# Ex 6: Trade Study – Determine Design Solution 1 of 4

<b>Total Budget (BAC):</b>	<b>1000</b>
– <b>Test and evaluate candidates (cand):</b>	<b>600</b>
• <b>Original estimate: 4 candidates</b>	
• <b>150 per candidate</b>	
– <b>Milestone (MS) 1, test setup:</b>	<b>25</b>
– <b>MS 2, Tests completed:</b>	<b>75</b>
– <b>MS 3, Test results analyzed</b>	<b>50</b>
• <b>Take 100% EV even if candidate is discarded before test complete</b>	
– <b>Down select to 2 candidates,</b>	<b>150</b>
– <b>Document final recommendation:</b>	<b>250</b>



# Ex 6: Trade Study

## Original PMB 2 of 4

Task	Jan	Feb	Mar	Apr	May	June	BAC
	BCWS	BCWS	BCWS	BCWS	BCWS	BCWS	
Cand 1	25	75	50				150
Cand 2	25	75	50				150
Cand 3		25	75	50			150
Cand 4		25	75	50			150
Subtotal	50	200	250	100			600
Select 2 cands					150		150
Recom- mend						250	250
Total Current BCWS	50	200	250	100	150	250	1000
Cumu- lative BCWS	50	250	500	600	750	1000	1000



## Ex 6: Trade – Determine Design Solution 3 of 4

- **Project on schedule but candidate (cand) 2 failed in Feb, after completing 50% of test**
- **A new candidate, # 5, was discovered and added in March.**
  - *Not additional scope or budgetable from MR.*
  - *Cannot establish “EAC” work package because of need to track progress with EV*
  - *Allocate budget for cand 5 from Budgeted Cost of Work Remaining (BCWR) of open work packages.*
  - *Must baseline in original period of performance even if ETC extends further.*
- ***As often happens, there is a need to develop an internal replan because of changing conditions.***



# Ex 6: Trade Study Internal Replan

## 4 of 4

Task	Jan	Feb	Cum BCWP	BCWR (a)	Transfer 20% to New Cand (b)	New BCWR	Mar	Apr	May	June	Original BAC	Re-plan BAC	
<b>BCWP</b>							<b>Replanned BCWS</b>						
Cand 1	25	75	100	50	-10	40	40				150	140	
Cand 2 (e)	25	125	150	0		0					150	150	
Cand 3		25	25	125	-25	100	50	50			150	125	
Cand 4		25	25	125	-25	100	50	50			150	125	
New Cand 5 (c) (d)	0	0	0		60	60		60				60	
Down-select 2 candidates				150		150			150		150	150	
Make recommendation				250		250				250	250	250	
Current BCWP	50	250	300	700		Current BCWS	140	160	150	250	1000	1000	
Cumulative BCWP	50	250	250	-250									

(a) BCWR = Budgeted Cost of Work Remaining

(b) Transfer 20% of BCWR from open work packages to new work package for replanned PMB

(c) Period of Performance for new work package cannot exceed Cand 4, even if ETC extends further.

(d) Cand. 5 is not additional scope. SOW is to select best candidate. No use of MR.

(e) Cand. 2 is 100% complete even though the test was aborted. Objective was achieved.



# Rework



# Why Plan Rework Separately?

- **Better knowledge of schedule progress towards *initial* development of requirements, design, code**
  - **Earlier warning of slip to completion of initial development**
  - **Better cost variance analysis**
- **Better cost and schedule variance analysis**



# NAVAIR on Rework



- **Plan rework in separate work packages from the initial development of**
  - **Requirements**
  - **Design**
  - **Code**
- **All incremental builds must include budget and schedule for rework to correct defects that were found in the current and previous builds**



# **Solution to Plan and Track Rework Discretely (1 of 3)**

- **Verify realistic rework assumptions and estimates are included in suppliers' proposals and negotiated values**
  - **Including productivity/quality measures such as rework % and defect density**
- **Review adequacy of budget and schedule for rework that is included in PMB vs. MR**
  - **Verify during IBRs and technical reviews**



# Solution to Track Rework Discretely (2 of 3)

- **Option 1: (Preferred) Rework is in a separate work package**
  - **Discrete EV based on technical maturity targets**
  - **Establish interim milestones with associated TPM planned values or quantified functionality based on meeting requirements**
  - **Take interim EV based on net achieved technical performance**
    - **Make negative adjustment to earned value when necessary for accurate status reporting**



# Solution to Track Rework Discretely (3 of 3)

- **Option 2: If rework is not in a separate work package and if EV was taken for achieving a technical milestone, make negative adjustment to EV when work product is returned**
- **Cumulative EV must reflect net technical progress**



# Ex 7: Negative EV for Rework in Same Work Package

- **SOW: 50 drawings to design a product**
- **PMB: 2000 hours over 5 months**
- **Rework was not planned in a separate work package**
  
- **Status at end of 4<sup>th</sup> month:**
  - **Behind schedule to complete initial drawings**
  - **5 drawings returned for rework**

***Lesson: Drawings Returned for Rework Cause Negative EV***



# Ex 7: Negative EV for Rework in Same Work Package

<b>Design (drawings)</b>	<b>Jan.</b>	<b>Feb.</b>	<b>Mar.</b>	<b>Apr.</b>	<b>May</b>	<b>Total</b>
<b>Planned drawings –cur.</b>	<b>8</b>	<b>10</b>	<b>12</b>	<b>10</b>	<b>10</b>	<b>50</b>
<b>Planned drawings –cum.</b>	<b>8</b>	<b>18</b>	<b>30</b>	<b>40</b>	<b>50</b>	<b>50</b>
<b>BCWS – cum.</b>	<b>320</b>	<b>720</b>	<b>1200</b>	<b>1600</b>	<b>2000</b>	<b>2000</b>
<b>Drawings completed</b>	<b>9</b>	<b>10</b>	<b>10</b>	<b>4</b>		
<b>Drawings returned</b>				<b>- 5</b>		
<b>Net drawings – cur.</b>	<b>9</b>	<b>10</b>	<b>10</b>	<b>-1</b>		
<b>Net drawings – cum.</b>	<b>9</b>	<b>19</b>	<b>29</b>	<b>28</b>		
<b>Net EV – cur.</b>	<b>360</b>	<b>400</b>	<b>400</b>	<b>-40</b>		
<b>EV – cum.</b>	<b>360</b>	<b>760</b>	<b>1160</b>	<b>1120</b>		
<b>SV – cum.</b>	<b>0</b>	<b>40</b>	<b>-40</b>	<b>-480</b>		



# Acquisition Management



# Acquisition Management

*Ensure Contractors Integrate Technical Performance/Quality with EVM*

**Guidance from:**

- **CMMI for Acquisition (ACQ)** 
- **Space and Missile Systems Center (SMC)  
Standard SMC-S-001 Systems Engineering  
Requirements and Products**



# CMMI-ACQ

## Acquisition Technical Management

### SP 1.1 Subpractices

3. Identify **the quality and functional attribute requirements** to be satisfied by each selected technical solution
  - **Use a traceability matrix** to identifying the requirements for each selected technical solution and relates requirements to work products
4. Identify analysis methods to be used for each selected technical solution
  - Simulations, prototyping, architectural evaluation, demonstrations



# Space and Missile Systems Center (SMC)

## Systems Engineering Requirements and Products

### 4.1.2 System-Level Constraints, Concepts, and Architectures

- **Required SE products** with the **product attributes** specified in this document.



# SMC SE Products: Design Solution

## 4.2.3.1 Required SE Products:

- **Validated, approved, and maintained (design-to) baseline**
  - In specifications and interface documents
  - Grouped by each system element such as
    - Segment
    - Subsystem
    - Component (hardware and software)



# SMC Shall: Plan the SE Effort

## 5.2.1.1 Planning

### 5.2.1.1.1 Required SE Products

- In IMP: **SE accomplishments, accomplishment criteria**, narrative
- IMS: tasks
- EVMS: work packages





# SMC Shall: Monitor Progress Against the Plan

## 5.2.1.2 Monitoring

Contractor **SHALL** monitor progress against plan to validate, approve, and maintain each baseline and functional architecture

### 5.2.1.1.1 Required SE Products

- Documented SE assessments linked in database to initial plans
- Results of each iteration to include tradeoffs

### 5.2.1.1.2 Required Product Attributes

- a. Each documented assessment includes:
  - **TPMs**, metrics
  - Metrics and technical parameters for tracking that are critical indicators of technical progress and achievement and include system parameters, configuration item (CI) parameters, or both



# Proposed EVM Acquisition Reform



# Revise Acquisition Policy and Regulations

- **Federal**
  - OMB policy and FAR
- **DoD**
  - DFARS
  - DoDI 5000.02
  - DoD acquisition and SE guides





# Interim Solution: New Contract Requirements (1 of 2)

- **New contract requirements in SOW**
- **Objectives:**
  - **Refocus management attention from work scope to the product scope**
  - **Focus on technical performance**
- **Means:**
  - **All requirements via SOW**
  - **Or combination of SOW and tailored EVMS Guidelines**



# Interim Solution: New Contract Requirements (2 of 2)

- For top down planning, make the IMP a contractual requirement and use a tailored CWBS DID.
- Specify EVM techniques in the SOW and/or use tailored EVMS guidelines or to:
  - Incorporate the product scope or technical baseline in the PMB.
  - Tie EV to technical performance.
  - Account for deferred functionality.
  - Track specified SE tasks discretely.
  - Plan rework and track it discretely.

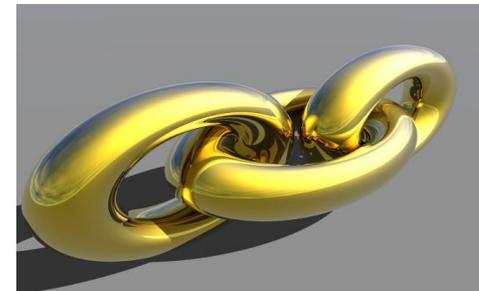
Note: Detailed contractual guidance is proposed in *CrossTalk* article, “Basing Earned Value on Technical Performance,” Jan. 2013

URL <http://www.pb-ev.com/Pages/AdvancedEV.aspx>



# Program Management Tips

- **Make IMP a contractual requirement**
- **Require SE best practices and tailored EVMS clause in RFP and SOW**
- **Verify compliance in Integrated Baseline Review (IBR)**
- **Confirm achievement of success criteria in technical reviews**
- **Monitor consistency and validity of status reports, variance analyses, EAC**
- **Close the Quality Gap**





# IBR: SE Implementation Review

- **Requirements management and traceability**
- **Milestones for SE requirements work products by WBS**
  - Derived requirements
  - Definition of required functionality and quality attributes
  - Verification methods and criteria
- **Milestones for establishing product metrics**
  - SFR: MOEs, MOPs defined
  - PDR: TPMs defined



# IBR: SE Implementation Review

- **Milestones with technical maturity success criteria**
  - TPM planned values
  - Meeting requirements
  - Percent of designs complete
- **Define entry and success criteria for event-driven technical reviews/IMP events**
  - **Revise/clarify criteria for CDR and subsequent events based on**
    - Knowledge of revised and derived requirements to be met
    - TPM planned values
- **Flow down of SE milestones to work packages**
- **Define correct base measures of EV**



# Framework for Process Improvement

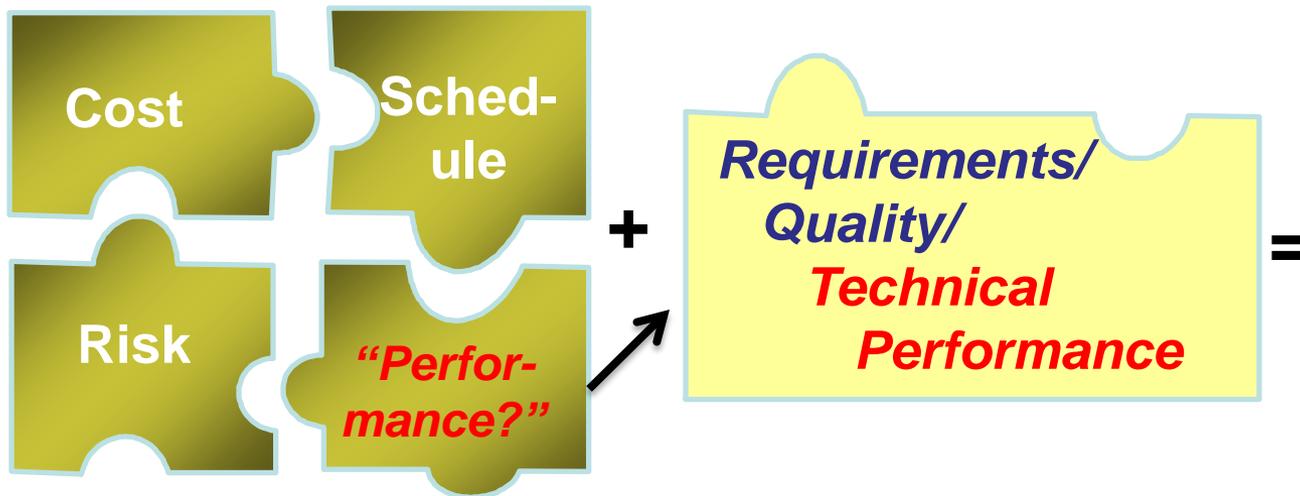


# Process Improvement Goal

**EVMS**

**SE**

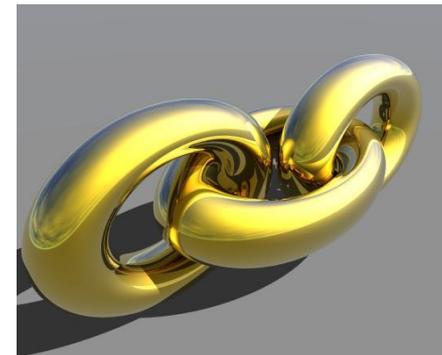
**Integrated  
Planning**





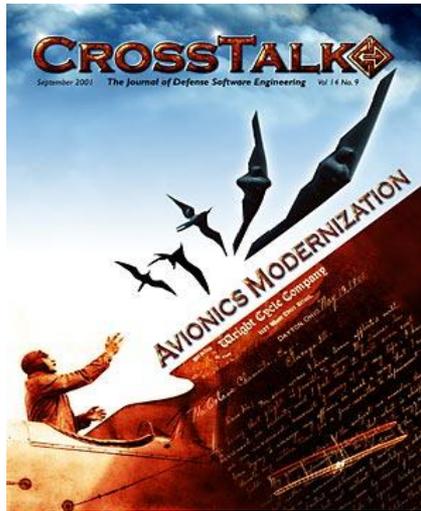
# Close the EVMS Quality Gap

- **PMB includes technical/quality parameters**
- **Insightful IBRs and technical reviews**
- ***Valid* contract performance reports**
  - **Objective technical/schedule status**
  - **Credible EAC**
- **Early detection of problems**
  - **Program performance**
  - **EV measurement and compliance**
- **Consider revisions to**
  - **DFARS**
  - **DoDI 5000.02**

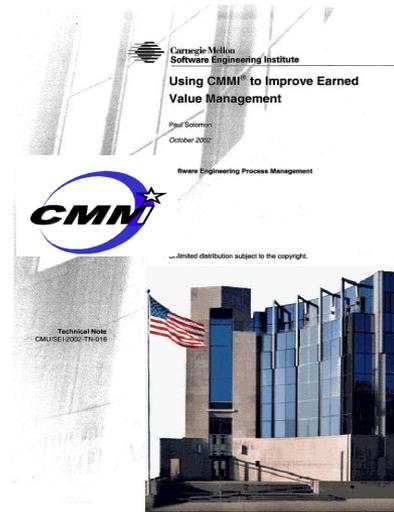




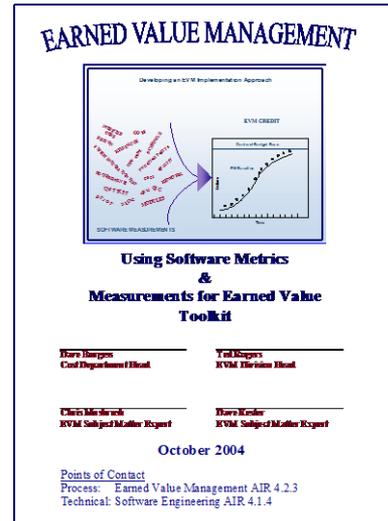
# Resources Online



DOD



SEI



NAVAIR



DOD DAU



ICFAI U.  
Press, India



College of  
Performance  
Management  
"Measurable News"



[www.PB-EV.com](http://www.PB-EV.com)

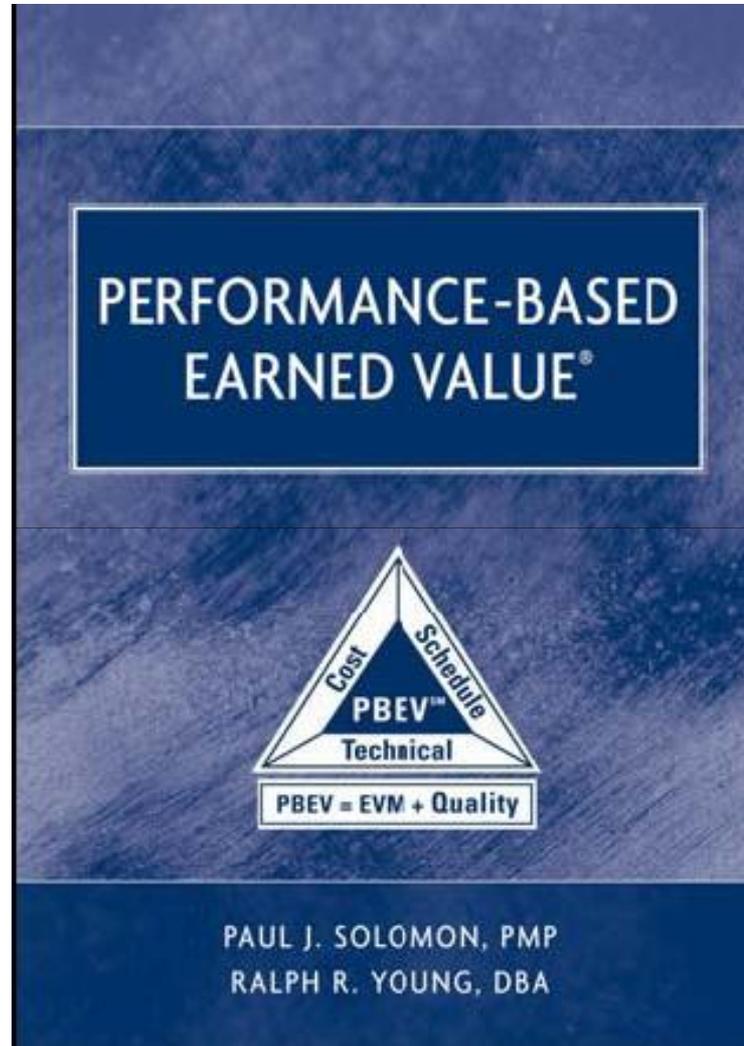


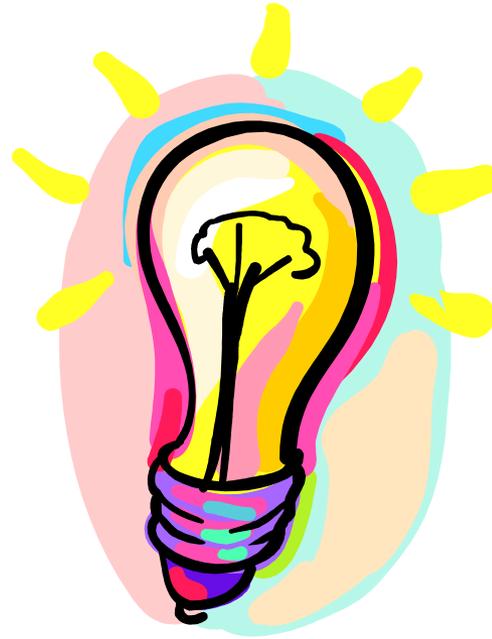
# Process Improvement Resources

Book includes

- Examples
- Templates
- Tips
- Standards
- Acquisition guidance

Published by:





**Questions?**

**Comments?**



# References

- ® **CMMI Is Registered by Carnegie Mellon University in the U.S. Patent and Trademark Office.**
- ® **Performance-Based Earned Value is registered by Paul Solomon in the U.S. Patent and Trademark Office.**
- ® **PMBOK is registered by the Project Management Institute in the U.S. Patent and Trademark Office**
- **American National Standards Institute (ANSI)/Electronics Industries Alliance (EIA). ANSI/EIA 632, *Processes for Engineering a System*, EIA, Arlington, VA, 1998.**
- **CMMI®, *Capability Maturity Model Integration for Development, Version 1.2*, 2006.**
- **CMMI, *CMMI for Acquisition, Version 1.2*, 2007.**
- **CMMI, *Using CMMI to Improve Earned Value Management*, 2002**
- **INCOSE 2006. International Council on Systems Engineering (INCOSE). *INCOSE Systems Engineering Handbook, version 3*. June 2006. page 7.11**
- **Institute of Electrical and Electronics Engineers (IEEE). ISO/IEC 26702:2007/ IEEE Std 1220™-2005, *IEEE Standard for Application and Management of the Systems Engineering Process*. New York, 2005.**
- **Naval Air Systems Command (NAVAIR). “*Using Software Metrics & Measurements for Earned Value Toolkit*.” Department of the Navy (October 2004)**
- **Data & Analysis Center for Software (DACs). *SoftwareTech News*. April and Sept. 2009**



# Acronyms/Contact

**PMBOK Guide® is registered by the Project Management Institute in the U.S. Patent and Trademark Office**

**CDR: Critical Design Review**

**EAC: Estimate at Completion**

**EVM: Earned Value Management**

**IBR: Integrated Baseline Review**

**IMP: Integrated Master Plan**

**IMS: Integrated Master Schedule**

**KPP: Key Performance Parameter**

**MOE: Measure of Effectiveness**

**MOP: Measure of Performance**

**OMB: Office of Management and Budget**

**PDR: Preliminary Design Review**

**PMB: Performance Measurement Baseline**

**SE: Systems Engineering**

**SFR: System Functional Review**

**TPM: Technical Performance Measure**

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**Just in Case**



# TPM (CMMI/DAG)

<p><b>Requirements Development</b></p>	<p><b>SG 3: Analyze and Validate Requirements</b></p>	<p><b>DAG</b></p>
<p><b>SP 3.3</b></p> <p><b>Analyze Requirements</b></p>	<p><b>Example work products:</b></p> <ul style="list-style-type: none"> <li>• Requirements defects reports</li> <li>• Key requirements</li> <li>• <b>TPMs</b></li> </ul> <p><b>Subpractices</b></p> <p>4. Identify key requirements that have as strong influence on cost, schedule, functionality, risk, or performance</p> <p>5. Identify <b>TPMs</b> that will be tracked during the development effort</p>	<p>2.1.1.4, 4.5.6.1 TPMs</p>



# TPM (CMMI/DAG)

Measurement and Analysis	SG 1: Align Measurement and Analysis Activities	DAG
<p data-bbox="98 468 291 525"><b>SP 1.2</b></p> <p data-bbox="98 575 397 701"><b>Specify Measures</b></p> 	<p data-bbox="614 468 1238 525"><b>Example work products:</b></p> <p data-bbox="614 554 1406 646"><b>Specifications of base and derived measures</b></p> <p data-bbox="614 689 952 746"><b>Subpractices</b></p> <p data-bbox="614 782 1335 1003"><b>3. Specify operational definitions for the measures..in precise and unambiguous terms</b></p>	<p data-bbox="1464 468 1628 518">4.5.4.2,</p> <p data-bbox="1464 546 1599 596"><b>WBS:</b></p> <p data-bbox="1464 625 1725 739"><b>Objective measures..</b></p> <p data-bbox="1464 775 1754 868"><b>essential for EVM...</b></p> <p data-bbox="1464 903 1705 1053"><b>integrated with TPMs and CTPs</b></p>



# TPM (CMMI/DAG)

<p><b>Project Monitoring &amp; Control</b></p> 	<p><b>SG 1: Monitor Project Against the Plan</b></p>	<p><b>DAG</b></p>
<p><b>SP 1.1</b></p> <p><b>Monitor Project Planning Parameters</b></p>	<p>Monitor <b>actual values of planning parameters against plan</b></p> <p>Subpractices:</p> <p>Monitor:</p> <ol style="list-style-type: none"> <li>1. Progress against schedule</li> <li>2. Cost</li> <li>3. <b>Attributes of work products</b> and tasks</li> </ol>	<p>4.5.6.1</p> <p><b>TPMs and CTPs</b></p>